MEMORANDUM

1 February 1982

TO: NWTPR

FROM: J. Goetz

SUBJECT: Acid Residue And Radioactivity From Decontamination of Crossroads Non-Target Ships

Approximately 6000 gallons of acid were used to clean the internal piping of the Rockbridge. The piping was contaminated with fission products and unburned plutonium, intimately mixed with the usual build-up in pipes, such as calcium carbonate. A typical cleansing reaction is:

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

It is assumed that the pipe contamination on 1 December 1946 amounted to 1 Curie of fission products (about the same as hull readings, converted to activity) and 6.4 microCuries (100 μg) of plutonium, and that 90 percent of the radioactive materials were removed in the cleaning process, remaining intimately mixed with the salt and water residues. These residues were then placed in drums (55-gallon) for transport to disposal areas.

If the contents of these drums were diluted 4 to 1 as they were being dumped into a large body of water, the total dilution, together with the inherent shielding of water, would have rendered the material virtually harmless. For example, mixing the contents with a column of water 40 feet deep and 3000 feet in diameter (2.2 billion gallons) results in a dilution factor of 350,000. This results in a dilution of the original Curie of radioactivity to .13 $\mu Ci/m^3$. Considering that only the top 4 inches (10 cm) of activity can contribute to an above-water dose, the concentration at the surface is therefore .013 $\mu Ci/m^2$.

At 90 days after burst (1 December), the above concentration results in an intensity above the surface of:

$$\frac{.013}{256} = .00005 = 5 \times 10^{-5} \text{ mr/hr}$$

(256 is conversion of $\mu Ci/m^2$ to mr/hr at 2160 hours)

The dose to a person exposed above this pool for 1 year (assuming no further dilution) is:

$$D = (5)(5 \times 10^{-5})(2160^{1.2})(2160^{-.2} - 10920^{-.2})$$

$$= 0.15 \text{ mr}$$

$$= 0.1 \text{ mrem in the year (December 1946 to December 1947)}$$

The plutonium in the residues presented no external hazard. When the drums were emptied, the plutonium likely mixed with the water as soluble plutonium oxide and was diluted to insignificance. The 100 μg, if diluted in 2.2 billion gallons of water (the 40-foot column), would present no significant contamination hazard.

WORKER HAZARD

An external gamma radiation dose hazard would have existed from the stored fission products. The concentration of these products was:

$$(.9 \times 1)/(6000) \times 55 = 8 \text{ mCi per drum}$$

As a point source of radiation, this concentration (assuming 0.7 Mev average energy) leads to 2.8 mr/hr (p. 32, Rad-Health Handbook). As a drum source, the self-shielding is a factor of three. Thus, the fission products would have presented an external gamma hazard to workers handling the drums. The 0.9 mr/hr intensity per drum leads to a maximum intensity of approximately 10 mr/hr for persons standing near an array of these drums.